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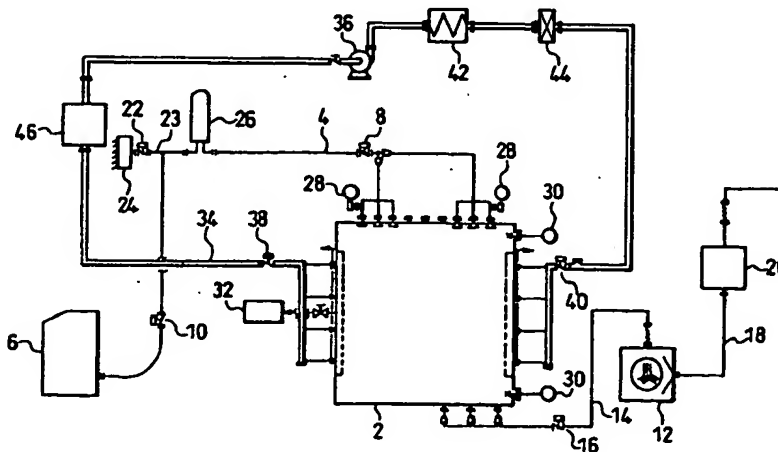
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(54) **Apparatus and method of sterilization**

(57) Connected to a sterilizing chamber 2 which contains an article are a hydrogen peroxide gas feeder 6, a vacuum pump 12 for drawing gas from the chamber, and an air inlet 24 which is connected through a sterilizing filter 26. Also connected to the chamber 2 is a circulation path 34 including an outlet valve 38, a circulating fan 36 and an inlet valve 40, and a platinum catalyst 46 is disposed in the circulation path 34. Initially, an article is contained in the chamber 2, which is drawn to a vacuum condition, whereupon hydrogen peroxide gas is fed to the chamber for sterilization. The suction and

the gas feeding are alternately repeated. After the sterilization, the vacuum pump 12 draws gas from the chamber 2 to establish a vacuum condition. Sterilized air is then introduced into the chamber 2, thus recovering a pressure which is slightly below the atmospheric pressure. Valves 38, 40 in the circulation path 34 are opened and the circulating fan 36 is operated, causing the gas in the chamber 2 to circulate. Hydrogen peroxide gas is adsorbed by platinum, allowing a degassing operation to be completed in a reduced length of time.

FIG.1



## Description

### BACKGROUND OF THE INVENTION AND RELATED ART STATEMENT

The invention relates to an apparatus for and a method of sterilization which takes place by containing an object or article in a sterilizing chamber, into which a sterilizing gas is fed for purpose of sterilization.

A sterilization by way of a sterilizing gas has been used in the conventional practice for a container formed of a resin, for example, such as an injection syringe or eyedropper for which steam or dry hot sterilization cannot be used. Such a gas sterilizer generally comprises a sterilizing chamber which can be sealingly enclosed to contain an article therein, a sterilizing gas feeder connected to the chamber through a valve for feeding a sterilizing gas thereto, a vacuum pump for drawing gas from the chamber, and an air inlet connected to the chamber through a valve for introducing sterilized air which is passed through a sterilizing filter into the chamber. Normally, an article to be sterilized is received in the chamber, which is then drawn by the vacuum pump to achieve a vacuum condition at a given pressure within the chamber. The sterilizing gas feeder then feeds the gas into the chamber for permeation or immersion of the article for purpose of sterilization.

After the sterilization, the vacuum pump draws sterilizing gas from the chamber to be displaced therefrom, followed by the introduction of sterilized air into the chamber. By repeating the steps of drawing by the pump and introducing sterilized air, sterilizing gas is removed from the chamber, and the sterilized article is then removed from the chamber.

A sterilizer of the type mentioned above is known in the art, and a conventional sterilizer uses ethylene oxide gas or the like as the sterilizing gas (see Japanese Patent Publications No.9,456/1985 and No.36,541/1984). The use of ethylene oxide gas for sterilization involves a problem that a sterilization cycle becomes longer. In particular, it takes a long time for a degassing step or displacement of sterilizing gas from the chamber upon completion of the sterilization process. In addition, ethylene oxide gas is strongly toxic, causing adverse influences upon men and global environment. The influences upon men and global environment are even more significant inasmuch as toxicity remains in decomposed products from the sterilization process.

To avoid the length of time required for the degassing step which follows the sterilization process when ethylene oxide gas is used as sterilizing gas, there has been proposed to connect a circulation path, which forms a closed circuit, to a sterilizing chamber in order to allow sterilizing gas to be displaced from the sterilizing chamber within a reduced length of time. The air which is fed into the chamber after the vacuum condition is established therein is passed through the circulation path, thus circulating it (Japanese Patent Publication

No.9,456/1985). However, the air circulation through the path to mix sterilizing gas and air to promote the fluidity is insufficient to accelerate the degassing step.

### 5 OBJECT AND SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide an apparatus for and a method of sterilization which are capable of reducing the time required for the sterilization cycle by accelerating the degassing step which follows the sterilization while avoiding adverse influences upon human bodies and environment.

Above object is accomplished in accordance with the invention by providing an apparatus for sterilization comprising a sterilizing chamber capable of containing an article, a hydrogen peroxide feeder connected to the chamber, a vacuum pump connected to the chamber for drawing gas therefrom, an air inlet connected to the chamber through a filter, a circulation path connected to the chamber through an outlet valve and an inlet valve, a circulating fan provided in the circulation path, and a catalyst disposed within the circulation path.

Also, above object is accomplished in accordance with the invention by providing a method of sterilization comprising the steps of using a vacuum pump to draw an air from a sterilizing chamber which is sealingly enclosed to contain an article therein, feeding hydrogen peroxide gas to the chamber for sterilization of the article, repeating the drawing step and the feeding step a plurality of times, subsequently introducing sterilized air into the chamber, causing gas in the chamber to circulate through a circulation path connected to the chamber through a valve, and passing the gas through a catalyst disposed within the circulation path to remove the hydrogen peroxide gas.

When the method of sterilization is carried out using the apparatus for sterilization, hydrogen peroxide gas is fed to the sterilizing chamber which is maintained vacuum by operation of the vacuum pump, thereby sterilizing the article contained in the chamber. The step of drawing vacuum and the step of feeding hydrogen peroxide are alternately repeated to achieve a perfect sterilization. Subsequently, air is introduced into the chamber, and a gas mixture comprising the air and the hydrogen peroxide gas is circulated through the circulation path, whereupon the hydrogen peroxide gas in the mixture is adsorbed by the catalyst, thus reducing the concentration of hydrogen peroxide in the mixture gas.

### 50 BRIEF DESCRIPTION OF THE DRAWING

Fig.1 is a circuit diagram schematically illustrating an apparatus for sterilization according to one embodiment of the invention.

# DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

An embodiment of the invention will now be described with reference to the single drawing, which is a circuit diagram schematically illustrating the apparatus for sterilization according to one embodiment of the invention. A sterilizing chamber 2, which contains an article therein for sterilization, is connected through a gas pipe 4 to a hydrogen peroxide gas feeder 6. Valves 8 and 10 are disposed in the gas pipe 4 toward the chamber 2 and the feeder 6, respectively.

A vacuum pump 12, operative to draw gas from the chamber 2, is connected to the chamber 2 through a suction pipe 14 and a valve 16. Gas drawn by the pump 12 is passed through a downstream discharge pipe 18 having a catalyst 20 disposed therein to be exhausted externally or outdoors. An air inlet 24 is connected to a point in the gas pipe 4 located between the pair of valves 8, 10 through another valve 22 and an extension pipe 23. Air admitted through the air inlet 24 is introduced into the chamber 2 through a sterilizing filter 26 which is connected in the gas pipe 4. A pressure gauge 28 and a thermometer 30 are mounted on the chamber 2 to detect the pressure and the temperature within the chamber. A concentration meter 32 is also mounted to determine the concentration of hydrogen peroxide gas in the chamber 2.

A circulation path 34 is connected to the chamber 2 and forms a closed circuit together with the latter. A circulating fan 36 is connected in the circulation path 34, and valves 38 and 40 are also connected in the circulation path 34 at locations toward the outlet and the inlet, respectively, of the chamber 2. When the both valves 38 and 40 are open, the operation of the fan 36 allows gas in the chamber 2 to be circulated. To promote decomposition of hydrogen peroxide gas, a heater 42 which heats the circulating gas and a filter 44 are connected in the circulation path 34. A catalyst 46 is also disposed in the circulation path 34 to adsorb hydrogen peroxide gas contained in the air which circulates the path 34. In the present embodiment, platinum or palladium is used for the catalyst 46, whereby a simple passage of hydrogen peroxide therethrough enables a decomposition thereof in a facilitated manner.

A sterilization process which takes place with the apparatus for sterilization mentioned above will be described. Initially, an article to be sterilized is placed in the chamber 2, which is then sealingly enclosed by closing an access door. At this point, the interior of the chamber 2 assumes an atmospheric pressure.

The valve 16 connected in the suction pipe 14 connected to the vacuum pump 12 is then opened, and the pump 12 is operated, thus drawing air from the chamber 2 to achieve a vacuum condition. When a vacuum condition which corresponds to a given pressure is attained, the valve 16 associated with the pump 12 is closed while the valves 8 and 10 in the gas pipe 4 are

opened to begin and continue supplying hydrogen peroxide gas from the feeder 6 into the chamber 2 until the entire article to be sterilized is immersed in the hydrogen peroxide gas. It is to be noted that a chosen amount of hydrogen peroxide gas be supplied since when supplied in excess, the hydrogen peroxide no longer assumes a gas phase. It is also to be noted that since the air pressure in the chamber 2 is greatly reduced as a result of operation of the vacuum pump 12, the hydrogen peroxide gas has a high level of partial pressure.

Subsequently, the valve 22 associated with the air inlet 24 is opened to allow sterilized air, which is obtained by passage through the sterilizing filter 26, to be introduced into the chamber 2, raising the internal pressure thereof slightly above its initial vacuum condition. This condition is maintained for a few minutes, allowing the hydrogen peroxide gas to permeate into detailed features of the article. Sterilization is then continued by repeating a sequence of the suction step by the pump 12, the step of feed sterilizing gas and the step of introducing sterilized air several times.

After the article is sterilized by the steps mentioned above, the degassing step to remove hydrogen peroxide gas from the chamber 2 takes place. Again the vacuum pump 12 is operated to reestablish a vacuum condition corresponding to a given pressure within the sterilizing chamber 2 by drawing gas therefrom. After the vacuum condition is attained, the valve 16 associated with the pump 12 is closed while the valve 22 associated with the air inlet 24 and the valve 8 disposed in the gas pipe 4 toward the chamber 2 are opened, thus introducing sterilized air into the chamber 2 and raising the pressure within the chamber to a level slightly below the atmospheric pressure.

The valves 22 and 8 are then closed while the valves 38 and 40 connected in the circulation path 34 toward the outlet and the inlet of the chamber 2 are opened, and the circulating fan 36 is operated. The gas mixture of the air and the hydrogen peroxide gas circulates through the path 34. During the circulation, the catalyst 46 such as platinum adsorbs the hydrogen peroxide and the heating of the circulating gas by the heater 42 promotes the decomposition of the hydrogen peroxide gas, thus reducing the concentration of the hydrogen peroxide in the chamber 2.

When the gas circulation through the path 34 is continued for a given time interval, the concentration of the hydrogen peroxide will be significantly reduced. In this manner, by causing a circulation of an increased volume of air through the catalyst 46 subsequent to the sterilization, the decomposition and the removal of the hydrogen peroxide gas can be achieved in a reduced length of time. When the hydrogen peroxide gas is removed from the chamber 2, an access door of the chamber is opened to remove the article which is now sterilized. In this embodiment, the sterilization is achieved by using hydrogen peroxide gas which is not toxic. Accordingly, there is no adverse influence upon human bodies and

environment, and decomposition products from the sterilization are oxygen and water, which are harmless.

Alternatively, subsequent to the removal of the hydrogen peroxide gas through the air circulation through the circulation path 34, the valve 16 in the pipe 14 leading to the pump 12 as well as the valve 22 in the extension pipe 23 from the air inlet 224 and the valve 8 in the gas pipe may be opened while simultaneously operating the pump 12, thus continuously displacing gas through the chamber 2 while drawing the air through the air inlet 24.

In the apparatus of the embodiment, when placing or removing an article into or from the chamber 2, the access door of the chamber may be maintained fully open while the pump 12 is operated to displace gas, thus preventing any residue of hydrogen peroxide gas in the chamber 2 from flowing out of the chamber. It is to be understood that articles which can be sterilized by the apparatus of the embodiment are not limited to resin containers such as injection syringe or eyedropper, but that the invention is applicable to a variety of articles. The invention is particularly preferred for use with articles which are not heat resistant, and a perfect sterilization is assured even for an article which has a complicated configuration.

#### Claims

1. An apparatus for sterilization comprising a sterilizing chamber capable of containing an article therein, a hydrogen peroxide feeder connected to the chamber, a vacuum pump connected to the chamber for drawing gas therefrom, an air inlet connected to the chamber through a filter, a circulation path connected to the chamber through an outlet valve and an inlet valve, a circulating fan provided in the circulation path, and a catalyst disposed in the circulation path.
2. An apparatus according to Claim 1 in which a heater is provided in the circulation path.
3. An apparatus according to Claim 1 or 2 in which a filter is provided in the circulation path.
4. A method of sterilization comprising the steps of using a vacuum pump to draw gas from a sterilizing chamber which is sealingly enclosed to contain an article therein, feeding hydrogen peroxide gas into the sterilizing chamber for sterilization, repeating the steps of drawing gas and feeding hydrogen peroxide gas a plurality of times, subsequently introducing sterilized air into the chamber, circulating gas in the chamber through a circulation path which is connected to the chamber through a valve, and passing the gas through a catalyst which is disposed in the circulation path to remove the hydrogen peroxide gas.
5. A method according to Claim 4 in which the step of feeding hydrogen peroxide gas into the sterilizing chamber for sterilization comprises subsequent to feeding the hydrogen peroxide gas, introducing sterilized air into the sterilizing chamber, this condition being maintained for a given time interval.
6. A method according to Claim 4, further comprising subsequent to the step of removing the hydrogen peroxide gas, applying a suction to the sterilizing chamber from the vacuum pump while introducing air from an air inlet into the sterilizing chamber.
7. A method according to Claim 4, further comprising the step of operating the vacuum pump to displace gas when an article is placed into or removed from the sterilizing chamber.

FIG.1

